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AUTHOR Kearsley, Greg P.
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ABSTRACT

Cost estimates for Computer Assisted Instruction (CAI) depend crucially upon the particular assumptions made about the components of the system to be included in the costs, the expected lifetime of the system and courseware, and the anticipated student utilization of the system/courseware. The cost estimates of three currently operational systems (PLATO IV, TICCIT, Computer Curriculum Corporation) are considered in terms of these assumptions. The assumption made in cost comparisons that the instructional effectiveness of CAI is the same as that of traditional instruction is questioned. Future developments which will affect cost estimates of CAI are discussed. (Author/VT)

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The Cost of CAI:

A Matter of Assumptions

Greg P. Kearsley

Division of Educational Research Services
Faculty of Education, University of Alberta
Edmonton, Alberta, Canada
T6G 2G5

ABSTRACT

The costs of providing Computer Assisted Instruction (CAI) are examined. Cost estimates for CAI depend crucially upon the particular assumptions made about the components of the system to be included in the costs, the expected lifetime of the system and courseware, and the anticipated student utilization of the system/courseware. The cost estimates of three currently operational systems are considered in terms of these assumptions. The assumption of equal instructional effectiveness made in cost comparisons with traditional instruction is questioned. Future developments which will affect cost estimates of CAI are discussed.

THE COST OF CAI: A MATTER OF ASSUMPTIONS

Despite considerable attention over the years, the cost of CAI remains an important and open issue to the educational community. It is also a very complex issue to deal with because of the number of considerations and assumptions which underlie even the simplest of cost estimates. Furthermore, because costing CAI involves many subtle value judgements, almost all cost estimates are implicit assessments of the worth of CAI as an instructional methodology or medium. This makes the entire process of evaluating the cost of CAI a politically sensitive one.

Yet the issue remains important because the cost of CAI, or more importantly, educators' perceptions of the cost, is one of the major limiting factors in the development and implementation of CAI. Even if favourably impressed by the instructional effectiveness of CAI, educators are reluctant to utilize or support CAI if it is perceived as being prohibitively expensive. Polls of experts in CAI have consistently shown that the cost of CAI is considered the major obstacle to its widespread acceptance.

An additional complexity in making CAI cost estimates is the dynamic nature of the computing field where dramatic changes in technology can occur within a period of a few years. The current development of microprocessors and "personal" computing (including retail computer stores) is a good example of this and also an example which has definite implications with respect to CAI (to be discussed). Hence, previously made cost estimates of CAI can be invalidated by new developments in hardware, software and to a lesser extent, instructional methodology.

This article considers some of the major assumptions which underlie cost estimates of CAI and certain considerations involved in these assumptions. Cost estimates for some major existing systems are examined in light of this general discussion. The conclusion challenges a further assumption implicit in all CAI versus traditional instruction cost comparisons, discusses conditions which would optimize the cost of CAI, and mentions some future developments in the computing field which can be expected to radically alter the costs (and nature) of CAI.

Underlying Assumptions of Cost Estimates

There are three major assumptions which underlie cost estimates of CAI. The first assumption concerns what components of a CAI system should be included in the cost estimate and what aspects are considered to be negligible or not part of the cost. Five major categories of costs can be identified:

System Hardware
System Software
Telecommunications
Operating
Courseware Development

System hardware includes the cost of the CPU, necessary peripherals (e.g., disk and tape storage, I/O devices, front end processors, etc.) as well as student terminals. Many cost estimates are based on this component alone, and further, terminal costs are often not included but assumed to be user costs. Hardware estimates may be based upon purchase price, long-term leases or short-term rentals.

System software costs cover the cost of purchase/ rent of the operating system, course authoring languages, graphics/audio software, utility programs, etc. These costs are not infrequently excluded from cost estimates either because they are assumed to be negligible next to the hardware costs, or because they are difficult to estimate.

Telecommunication costs involve simply the transmission costs via voice-grade telephone lines, digital data networks, microwave, UHF television, or satellite transmission. Like the costs of terminals, the telecommunication costs are often considered to be user costs and excluded from estimates.

Operating costs include the salaries of computer operators, system analysts or programmers, system managers, teaching proctors or assistants, and also costs due to the use of facilities, buildings, and maintenance of all equipment. Costs such as these are often part of the regular institutional salaries or budgets and excluded from CAI cost estimates.

Finally, courseware development costs cover the time of the author(s) in writing, programming and debugging courses as well as the cost of producing any adjunct materials (e.g., audio tapes, slides, workbooks,etc.) and technical assistance in terms of programming, instructional design, etc. This also would include the continued maintenance, rewriting, and evaluation of courseware which will likely go on for the lifetime of the course. Because much courseware is produced on "borrowed" time and because courseware development is often considered "educational research", cost estimates very seldom include the costs of courseware development even though they may in fact be appreciable.

To summarize, of the 5 major components that could be included in a cost estimate of a CAI system, only the cost of the system hardware is typically included. Costs due to systems software, operations, courseware development, and telecommunications are often omitted from estimates based on

the assumption that they are negligible or not properly part of the cost estimate. While it is certainly true that system hardware costs will probably constitute the largest single cost factor, these other categories may be far from negligible in many CAI systems. This point will be elaborated in the case studies below.

The second major assumption necessary in CAI cost estimates concerns the expected usage of the system and courseware. This means the number of students (per day, week, term, etc.) who are expected to use the courses on the system. It also includes the number of places or institutions at which the system or courseware is expected to be used. Cost estimates are made on the assumption that a CAI system (or perhaps a particular course) will be used for so many hours per day, per week, per year. This usage data is then divided into the system costs to produce a cost per student hour estimate. Thus, the particular assumptions about the amount of use a system or course will receive will greatly influence the cost estimates. For example, for an IBM 1500 system, a 6 hour/day usage (no weekends) results in cost of $3.63 per student hour, a 10 hour/day (plus Sat. morning) results in a cost of $2.04 per student hour, and a 16 hour/day (plus 9hr. Sat.) results in a cost of $1.20 per student hour. Estimates such as this further assume that every terminal is operational and occupied during the entire period -- quite an unrealistic assumption.

The development costs of CAI systems and courseware are often assumed to be distributed over a number of institutions. Although this idea seems reasonable in principle, in practice relatively little transfer of systems or courseware has occurred in proportion to the number of CAI courses which have been developed. (Later in the case studies, we shall look at some of the few examples of successful distribution.) Reasons are primarily technical and political. Courseware is often too poorly documented to be used without closely studying the source code -- an effort which can almost be equivalent to writing a new course. Because of the lack of standardization of systems and author languages, transfering a course may require considerable rewriting or modification even when the transfer is to a supposedly identical system. On the political side, educators are often very reluctant to accept another person's approach to teaching a subject, they may feel they have no control over "imported" curricula, or there may be copyright/royalty problems. For many reasons, assumptions about the distribution of CAI costs over many institutions have not been borne out in practice.

The third major assumption deals with the anticipated lifespan of the system and courseware. As far as systems are concerned, hardware/software which is purchased must be amortized over the expected life of the system. Given the

pace of development in the computer world, a system lifetime of 4-5 years seems most realistic, although some systems assume longer periods. As far as courseware is concerned, the lifespan will depend very much upon the the nature of the subject. Certain subject matters (e.g., arithmetic, reading, statistics) can be expected to have a relatively long lifetime and development costs can be amortized over periods of 10 years or more. Other subject matters will require major revision within a period of 3-4 years. Furthermore, even if the subject matter is relatively stable, views about the most effective instructional strategies change and hence limit the lifetime of courseware. Thus, assumptions about the lifespan of the system or courseware are probably unreasonable when made for periods in excess of 5-10 years. A further complication is that while a course may indeed exist for a long period, the course may have been constantly revised and modified over time such that after 3-4 years it is really quite different than when first written (yet still the same course). The additional development costs involved in such revisions are likely excluded from any cost estimates.

While there are other assumptions which enter into cost estimates of CAI, the three just discussed, assumptions about what is to be included/excluded in the estimate, the expected usage, and the expected lifespan, are major ones which underlie most estimates. The nature of these major assumptions can be further clarified by considering some basic attributes or variables which affect them.

Variables Affecting Cost Assumptions

One variable affecting cost assumptions is the type of CAI system involved. Three contrasting types are the large-scale, time-shared CPU with a large number of remotely located terminals, the timeshared minicomputer system serving a small number of local terminals, and the stand-alone mini or micro-processor serving a single student at a time. Each of the different types of systems will entail different purchase/rental agreements and hence cost assumptions. A large CAI system may consist of combinations of all three sizes in order to serve different instructional needs or optimize costs.

Another variable is the type and level of students. This can range across handicapped (e.g., deaf, blind, retarded, etc.), the underpriviledged (e.g., compensatory programs), professional students (e.g., medicine, law, dentistry, etc.), or adult/vocational training (e.g., airlines, military, trades). Within the domain of public education, the level of instruction could be elementary (basic skills such as reading, arithmetic), secondary (high school curricula) or advanced (undergraduate or graduate university or college). Each of these different types or

levels of students will involve different cost considerations.

Type of instruction is another factor to be considered. This refers to the way in which the computer is used for instruction. A broad but useful distinction is between CAI as adjunct instruction or as mainline instruction. As adjunct instruction, CAI provides supplementary or enrichment types of instruction which is in addition to existing instruction. This tends to be an add-on cost situation. As mainline instruction, CAI replaces the existing instruction and hence represents a replacement cost. CAI may be intended as drill & practice, as a laboratory tool or simulator, as a research technique, as a tutorial system, or as a necessary part of a computer managed system (in which the computer plays no actual instructional role). The intended use of the computer will also influence the nature of the assumptions about cost.

Instructional quality or complexity is a further variable which affects cost estimates. Courses which involve extensive audio or graphic components, remedial or enrichment sequences, alternative levels of difficulty, or student control features will require more programming and processing time. In addition, instructional features such as animation, color, different size or style of typefaces, etc., will make greater demands on the hardware and software. Thus, the sophistication of the courseware will affect system hardware, software, operating, and development costs. This is a variable which is extremely hard to estimate in terms of dollars and cents.

It should be appreciated that these variables are all interdependent. For example, if the intended goal is to provide mainline instruction to university students in a wide range of subjects and to maintain fairly detailed student records, a large-scale system (with large, fast memory capability) will likely be required. On the other hand, a fairly simple drill & practice program intended for supplementary use in elementary classrooms could best be handled by a small minicomputer system with 8-32 local terminals. A laboratory situation, involving computer simulations of experiments might be best served by a stand-alone microprocessor. Certain instructional strategies are often associated with particular levels or types of students, e.g., drill & practice with elementary or underpriviledged students, or tutorial with professional/advanced students.

The preceding discussion has identified some of the variables which are associated with assumptions made in cost estimates of CAI. Each particular combination of variables gives rise to certain costs and hence certain cost assumptions. In order to illustrate this in further detail

and examine some specific cost estimates, some case studies of CAI costs will be considered.

Case Studies of CAI Cost Estimates

The following case studies present the available cost estimates for three currently operational CAI systems. Each of these systems represents a different type of CAI system and involves different assumptions regarding costs.

The PLATO IV System.

PLATO IV is the prototype of a large-scale CAI system primarily designed to deliver mainline instruction in a wide variety of university and college subjects. The system is based upon the use of large CDC processors and a special plasma display terminal. Table 1 presents cost estimates for a system consisting of 4000 terminals and assumes 2000 hours of annual use per terminal (45 weeks x 44 hrs/week). The estimated total cost per student hour is $.34-.68. The system is assumed to have a lifetime of 5 years and costs are amortized over this period. These figures do not include courseware development costs which were estimated to be in the order of a few cents per student hour if as many as 10 PLATO IV systems were installed.

At the present time, PLATO IV is used at over 100 different sites and there are about 5 separate PLATO IV installations. Thus the assumption about distribution of development costs across institutions seems justified for PLATO. However, current PLATO IV systems have an upper limit of about 500 simultaneous users and therefore the per student estimates are out by a factor of 8. The largest variation in the cost estimates was due to the terminal cost. The optimistic cost was based upon the mass production of the plasma terminal resulting in a unit price of $1800. The present cost of the plasma terminal (which is still not mass produced) is still far in excess of this (between $5000-$10,000 depending upon capabilities), making even the upper estimate still too low. The cost estimate for communication costs is for local communication only -- long distance telecommunication by voice-grade lines is at least $1 mile/month making remote terminals at a distance prohibitively expensive. However, a single line can support a number of terminals (at present 4) and attention has been devoted to alternative telecommunication methods (e.g., Ball & Jamison, 1973). In addition, satellite or microwave transmission have been shown to be relatively inexpensive transmission modes for long distances.

The PLATO system was originally developed by the University of Illinois but recently has been marketed on a

commercial basis by CDC. This means that the PLATO system is now available on a service basis and can be rented according to actual courseware usage (rather than on a system basis). The costs of using CDC PLATO are about $1200/month per terminal, excluding telecommunication costs (this covers the rental & maintenance of the terminal and access to courseware). Because of the high costs associated with the plasma terminal and communications, the cost of the PLATO system is still far in excess of the per student hour costs estimated in Table 1.

The TICCIT System.

The TICCIT system was originally developed by the MITRE Corporation with the intended purpose of being a low-cost CAI system to be used to provide mainline instruction at introductory levels in a community college environment. The target costs were a complete system for under $500,000 which would provide instruction for under $1 per student hour. Hardware costs for the prototype TICCIT system are given in Table 2. The system uses off-the-shelf color TV sets and specially designed keyboards. For a single system consisting of 128 terminals, the cost per terminal is $3600. This figure is divided by the expected student usage to derive a cost per student hour. Making the same assumptions as made for PLATO IV (i.e., system lifespan of 5 years and 2000 annual hours of use), the hardware costs are $.36 per student hour. Because the terminals are local, the TICCIT system involves no telecommunication costs.

The cost for the software and operating are not given for the TICCIT system. Because of the system's size, operating costs are probably relatively minor. Courseware development for TICCIT was accomplished by a team at Brigham Young University. Because the courseware is fairly elaborate instructionally and produced on a full-time basis by a specialized team, courseware development cost are likely to be high. Estimates for courseware production typically range from $300 to $3000 per instructional hour. The TICCIT system is currently being used at a number of community colleges in the U.S. and hence these development costs can distributed over a number of institutions.

Computer Curriculum Corporation.

Computer Curriculum Corporation (CCC) offers minicomputer-based CAI systems which provide supplementary instruction in the basic skill areas of arithmetic, reading, and languages. The systems consist of 8-32 terminals and are intended to be located in classrooms. Table 3 presents the estimated annual costs of a CCC arithmetic system. The cost of the CPU is assumed to be $30,000. The estimates are for an 8 terminal system with an expected lifespan of 8 years. They calculate an annual per student cost of $50 per year

based upon a utilization rate of 25 students per day (not including summer months). Their cost estimate includes operating costs such as maintenance, teacher training, and teaching aides. These are costs which are usually excluded from cost estimates. However, system software costs and courseware development costs are excluded. CCC courseware is the result of a decade-long research program conducted by P. Suppes, R. Atkinson and colleagues at Stanford University. Thus, the costs of development would actually be quite high if they were to be estimated.

CCC has installed many of these systems in Southwestern U.S. using different miniprocessors and terminal types. Assumptions of distributed costs seem justified for CCC as well as the previous two cases. It is not known how the costs of these systems compare with the estimates given in Table 3, but they are likely more expensive.

Conclusions

As is evident from the preceding case studies, existing cost estimates of CAI almost always involve "hidden" costs of one kind or another. Besides these "hidden" costs, there are further problems. One is that estimates stated in dollars must be corrected for inflation. A second is that absolute cost estimates are relatively meaningless and only become useful when compared to the costs of existing or alternative instruction. For example, the cost estimates for the CCC system given in Table 3 resulted in an estimate of $50 per student per year for providing instruction in a single subject matter. The same instruction presented by existing means was estimated by Jamison, Suppes & Butler to be $89. Kopstein & Seidel (1968) compared the costs of CAI with traditional instruction at the levels of elementary/secondary, advanced, and military training. They concluded that CAI was far more expensive for elementary/secondary, but about equal for advanced and military instruction. (The U.S. Navy has reported it is now saving about $10 millon annually through its computer managed instruction program.)

If the cost estimates for CAI included all of the costs actually involved and more realistic assumptions about utilization and lifespans (or better yet, were based upon actual data), the cost of CAI would most likely be more than existing instructional methods for most subjects and students. How much more will depend upon the expertise underlying the development of the CAI system. The three systems described above in the case studies have had the benefit of considerable CAI "know-how" and hence provide nearly comparable costs; most new systems would not.

However, the fact that CAI results in a higher per student hour cost is based upon a fairly dubious assumption.

This is the assumption that the instructional effectiveness of CAI is the same as traditional instruction. This is most certainly an invalid premise. Almost all comparative studies of CAI have shown that CAI reduces the time required for a subject by 25-50% while still resulting in the same end performance. CAI permits a very detailed monitoring and evaluation of student performance and instructional effectiveness which is essentially impossible in traditional instruction. CAI also permits certain kinds of instruction which could not be done by any traditional means (e.g., medical simulations of dying patients). Students are overwhelmingly positive about CAI, and express strong preferences for this mode of instruction across all subjects. Thus, an hours worth of CAI may be instructionally equivalent to 2 hours (or more) of traditional instruction. If we accept this, then cost estimates which show CAI as costing the same as or slightly more than traditional instruction, in fact give CAI the edge.

In addition, cost estimates and comparisons of CAI are seldom made to optimize the costs from a CAI perspective since it is assumed that CAI systems must adapt to the traditional educational modes. Thus, traditional educational systems are group based in terms of rate of learning, evaluation, etc. However, individualized instruction means that the sort of timetabling and central facilties required by traditional instruction can largely be dispensed with giving rise to instruction dispersed in time and location. CAI can offer instruction at any place at any time which can mean considerable financial advantage if this can be capitalized upon. Likewise, the capability to allow students to progress at their own rates can also mean financial advantages if accepted.

There is one further aspect that should be weighed when making cost comparisons. This is the "cost" of providing computer literacy, i.e., general sophistication and experience interacting with computers. It is clear that man-machine interactions are already a major part of today's society and will become increasingly so in the future. Individuals who are unsophisticated with respect to computer technology will be severely disadvantaged in their vocational capability. Thus, computer literacy is a "hidden" cost benefit of CAI to the educational system.

Numerous future developments in the computing field favor decreases in the cost of CAI. One of these is the continued development of "personal" computers which will probably result in most homes having a small microprocessor system in the near future. A completely assembled microcomputer system with all the necessary peripherals and software can now be purchased for well under $2000. This is well within the range of many individuals and in fact, retail computer stores are now flourishing in the U.S. and

Canada. A second possibility is the development of interactive computer-controlled TV systems in which CAI is one of the capabilities available. Such TV systems are already being tested in Japan, Europe and the U.S. With the recent advent of commercial data communication networks, telecommunication costs will be dropping drastically. This will remove one of the cost obstacles to remotely located terminals.

Another consideration is that computers are beginning to play a wide variety of educational functions, most notably computer testing and guidance and hence the costs of hardware and software is shared with these other uses. Thus, most of the cost estimates of CAI are made on the assumption that the system will be completely dedicated to instructional usage. However, in many cases, a system mainly intended for administrative or library uses can also support a limited amount of instructional applications. The large-scale British computer assisted learning project (see Hooper & Toye, 1975) demonstrates how a diverse range of instructional applications can be quite compatible with other educational uses of the computer.

Finally, CAI has a built-in future success factor -- as it becomes more widely used, hardware and software costs go down due to mass production and dispersed costs. Thus there is little doubt that the costs of CAI will continually decrease (while the costs of traditional instruction continue to increase). But this conclusion is of little consolation to the department chairman, school administrator, or individual teacher who is faced with the task of justifying the present costs of CAI in next year's budget. Fortunately, with the right set of assumptions, it is possible to derive figures which show that some CAI systems are as cost effective as traditional instruction. In the not-too-distant future, the economics of CAI will probably be such that justification of CAI will be unnecessary in this fashion. Rather, the important question will be what type of CAI system will minimize costs for a particular instructional situation. This is when cost estimates of CAI will become non-trivial exercises.

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TABLE 1

Estimated Costs of the PLATO IV System.

(Alpert & Bitzer, 1970)

Component	Annual Costs (Thousand $)	Cost / Student Hour ($)
Central Computer	900	0.11
System Software	100	0.01
Terminals	1440-4000	0.18-0.50
Operating	240	0.03
Communications	72-200	0.01-0.03

TABLE 2

Estimated Costs of TICCIT Hardware.

(MITRE Corp., 1974)

Main Processor	$34,000
Terminal Processor	15,000
Card Printer	4,000
Line Printer	11,000
Tape Unit	9,000
Disc Drives (3)	41,000
Disc Control (3)	29,000
CRT Terminal	3,000
Computer-Computer Link	3,000
Character Generator	7,000
Keyboard Interface	6,000
Audio Response Subsystem	56,000
TV Monitors (128)	32,000
Keyboards (128)	22,000
Refreshers (128)	93,800
Signal Processors (128) & Cable	16,000
Video Tape Players (20)	17,000
Refresher Control	6,000
TV Modification	9,000
Crossbar Switch	17,000
Cabinets	7,500
Total (128 units)	441,000

TABLE 3

Estimated Costs of CCC System.

(Jamison, Suppes & Butler, 1973)

Component	Annual Cost ($)
System Hardware	4,640
Maintenance	3,000
Paraprofessionals	1,500
Teacher Training	500
Miscellaneous	300
Total	9,940

APPENDIX:

The Costs of CAI at the University of Alberta

The Division of Educational Research Services (DERS) in the Faculty of Education at the University of Alberta has operated an IBM 1500 system since 1968. The system consists of an 1130 CPU, multiplex controller, video buffer, 2 disk drives (50 megabytes on-line storage), 2 tape drives, printer, card reader, and 20 CRT terminals equipped with audio and slide projector units. The system software consists of the 1130 operating system, various utility programs for processing student records, a graphics subsystem, and an enhanced version of the COURSEWRITER II author language.

Although the major purpose of the DERS CAI system has been for research in learning, instructional design, measurement, etc., a number of courses have been developed which now serve a "mainline" teaching role. Thus, despite the research orientation, the DERS system currently fulfills a major instructional service to many students in different subject areas. This includes for instance, a course in cardiology for medical students (24 hours average), a graduate statistics course (60 hours average), a course in French for elementary and secondary students (30 hours average), a course in basic electronics for technical school students (50 hours average), and the CARE1 course in remedial education (26 hours average). Because the DERS CAI system supports such "mainline" courses, it is reasonable to look at the costs of the system in terms of a "production" type CAI system.

The basic monthly costs of the system are given in Table 4. The system software was provided by the vendor with the hardware-- thus, there are no rental costs for the software. Furthermore, the costs of maintaining and enhancing the software will be covered by the salaries of the system programmers and manager. The DERS system is available about 260 hours/month (10 hours Mon.-Fri., 8hr. Sat., 4 hr. Sun). Thus a monthly cost per terminal/hour for CAI service is about $3.92. It should be noted that the operating costs (which are "people" costs) account for a major proportion of the total costs and, in fact, are larger than either the CPU or terminal costs alone. This clearly substantiates the point made in the main text that operating costs may not be negligible. Furthermore, while hardware costs can be expected to decrease in the future, the costs of human resources are likely to escalate.

The actual number of student contact hours in 1976 was approximately 23,000 or 1917 hours/month (for 20 terminals). Thus, computed on the basis of actual use, the cost is $10.65 per student contact hour. The difference between the

$3.92 figure and the $10.65 figure is the difference between 100% usage and the actual usage of about 40%. The 40% utilization rate is due to a number of factors. There are a variety of scheduling problems such as the necessity of reserving a fixed time slot for an entire term when most of the students may complete the course early in the term or the reluctance on the part of instructors to schedule times in the evenings or on weekends (even when preferred or requested by students). Also to be taken into account is the fact that academic activity is greatly reduced during 4 months of the summer. Thus, much of the lower utilization rate is the result of accomodating a CAI system to the structure of traditional education.

The above costs are strictly those of providing the CAI service. There are two costs in addition to those discussed. One of these is the costs of providing tutors or teaching assistants for the courses. Even though most of the DERS courseware is self-contained, course tutors are usually available to assist students with questions and problems. The other cost not included in the above is the courseware development costs. The cumulative development costs for the major courses mentioned above range from approximately $10,000-$17,000. This figure includes all programming, debugging, graphic production, and evaluation via student records. It does not include the costs of producing audio tapes, slides or any ancillary materials. The actual distribution of these costs across time and student usage will depend upon the future use and lifetime of the courseware. (Most of the major courses have now been in continuous use for 2-3 years.) It is worth noting in passing that at least three major courses have been obtained from other institutions -- hence making their development costs negligible for DERS.

The preceding cost figures provide an indication of the actual costs of an operating CAI system in contrast to the (assumption-laden) estimates given in the main text of the paper. In considering these real costs, the following points should be borne in mind:

*the DERS CAI system is primarly intended for research purposes rather than full-time teaching service

*DERS courseware is instructionally sophisticated with full graphic, audio and slide capabilities and intended as "mainline" instruction

* the 1500 hardware could be functionally replaced by present-day hardware at a much lower cost

* the DERS system is completely dedicated to CAI

For these and other reasons, the actual costs of the DERS

CAI system probably present an upper limit on the present costs of CAI. There is no doubt that if DERS were asked to provide full-scale instructional service using present-day hardware, the actual costs would be very close to the $1-$3 per student hour range that convention instructional currently costs.

TABLE 4

Actual Costs of the DERS 1500 System.

	Monthly Cost ($)
System Hardware	
CPU & Peripherals	6,710
20 Terminals (with audio/slides)	
Rental cost	4,648
Maintenance cost	1,884
Operating	
3 Operators	3,198
2 programmers & syst manager	3,968
TOTAL	20,408